ISOLDE Workshop and Users meeting 2024

ISOLDE Superconducting Recoil Separator

The ISOLDE Superconducting Recoil Separator : design, prototypes, and plans for the future.

Ismael Martel

Universidad de Huelva

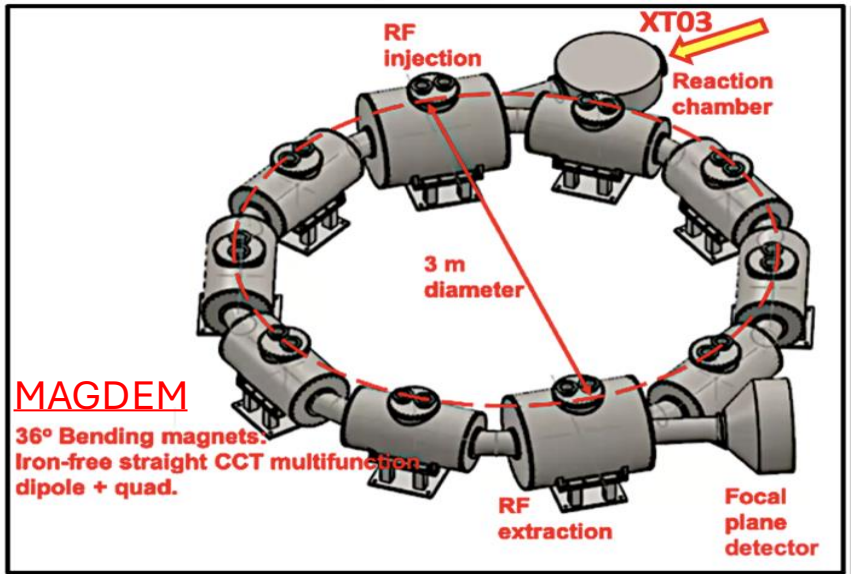
MINISTERIO DE CIENCIA E INNOVACIÓN
Plan de Recuperación, Transformación y Resiliencia
Financiado por la Unión Europea NextGenerationEU
CERN
HIE-ISOLDE

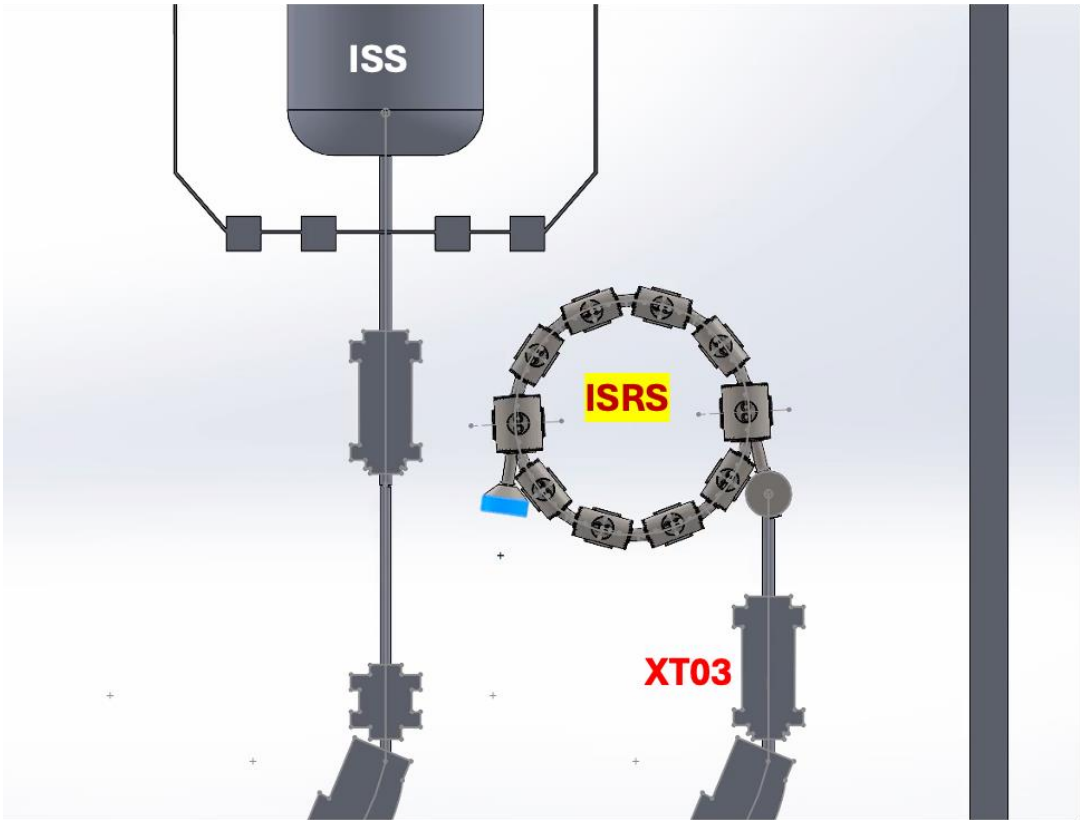
ISRS

The ISOLDE Supercondcuting Recoil Separator:

Conceptual design:

- Compact particle storage ring
- NS Fixed Field Alternating Gradients
- Superconducting magnets
- Multifunction-nested (dipole + quadrupole)
- Canted Cosine Theta (CCT) technology
- Cryocoolers “dry” technology (no LHe bath)
- Injection/extraction (RF, Suchi, etc)





LOI-INTC-228 (2021): Design study of a Superconducting Recoil Separator for HIE-ISOLDE. Spokespersons: I. Martel, et al. Nucl. Intr. and Meth. Phys. Res. B 541 (2023) 176

Funding

Spanish grant (RRF/EU): 3 MEuro. July 2023 – Dec. 2025. → Activity re-arranged; scope scaled to budget & timeline. → Univ. Huelva (Coordinator), ESS Bilbao, Univ. Valencia, IEM-CSIC-Madrid

6 months extension → June 2026

WP/TASK	LEADER
WP1: STUDY OF BEAM DYNAMICS, INJECTION AND EXTRACTION	**UV**
T1.1. Selection of Physics cases	UHU
T1.2. Nuclear reaction calculation	UHU
T1.3. Study of beam dynamics	UV
T1.4 Selection of configuration	UV
T1.5. Study of Injection/Extraction	UV
T1.6. Study of prototype of non-interceptive beam diagnostics	UV
T1.7. High order corrections to beam dynamics	CSIC
WP2: CCT SOLENOIDS AND CRYOSTATS	**UHU**
T2.1. Prototype of solenoid	UHU
T2.2. Prototype of solenoid with cryostat (MAGDEM)	UHU
T2.3. Study of elements of the magnetic field mesurement system	UHU
T2.4. MAGDEM focussing system	CSIC
T2.5. Prototypes of critical elements of focal plane	CSIC
WP3: MULTI-HARMONIC BUNCHER	**ESSB**
T3.1. Revision of critical designs	ESSB
T3.2. Test acceptance of manufactured protoypes	ESSB
T3.3. Prototype of multiharmonic buncher	ESSB

Experiments ISRS

Configuration de ISRS

Supercond. magnets

Test benches

Focal plane

MH buncher

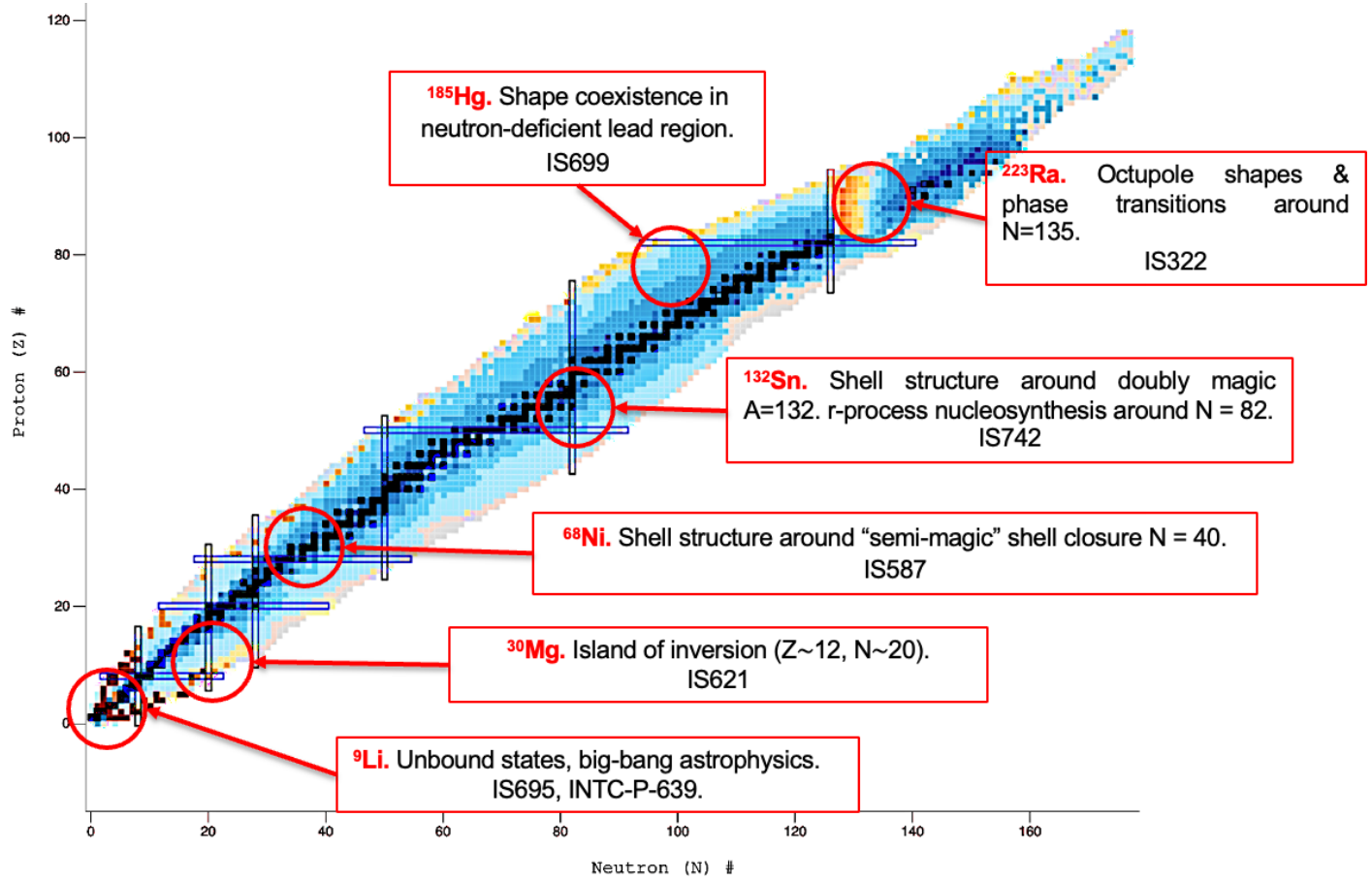
Minimum spectrometer requirements

Parameters	Values
Momentum acceptance	±10%
Resolving power $p/\Delta p$	2000
Angular acceptance	±10°
Angular resolution	0.1°
Solid angle	100 msr
Charge resolution $\Delta Q/Q$	1/70 (FWHM)
Mass resolution $\Delta M/M$	1/250 (FWHM)
Rotation	0 – 70°

ISRS – coupled to detector arrays

- ISS
- MINIBALL
- SEC
- SAND
- AGATA
- ISR (TSR)

Physics cases & simulations

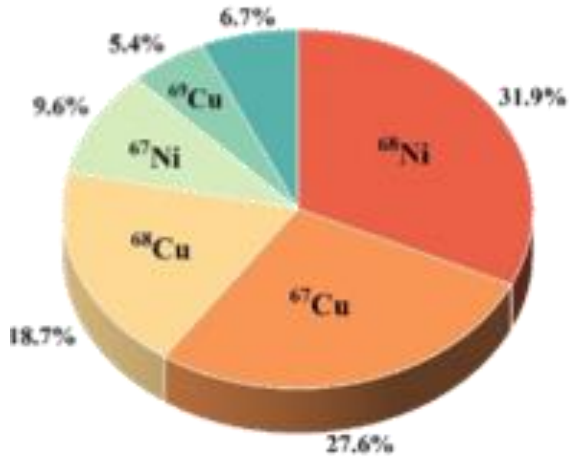


- Nuclear structure
- Reaction dynamics
- Astrophysics
- Fundamental interactions

- Direct reactions
  - ✓ Transfer
  - ✓ Coulex
- Fusion-evaporation

- EMPIRE
- FRESCO
- EXISTING DATA

^{68}Ni+d at the energy of 10 MeV/u

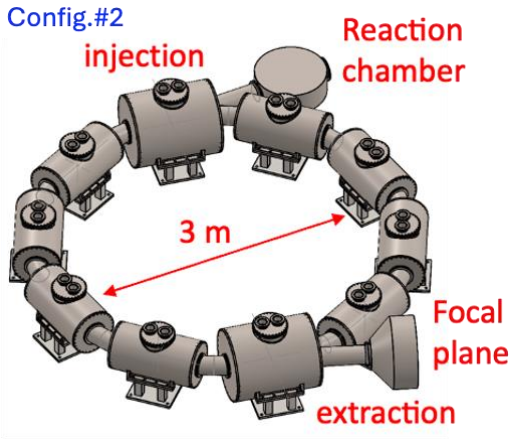


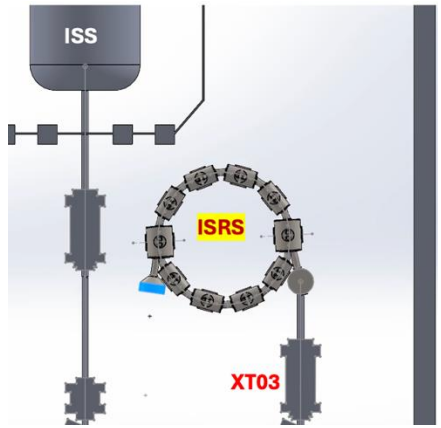
Residual nuclei (EMPIRE).

F. Torabi Universidad de Huelva

- Cross sections, Angular distributions, Kinematics,...
- ISRS physics working group

Beam dynamics

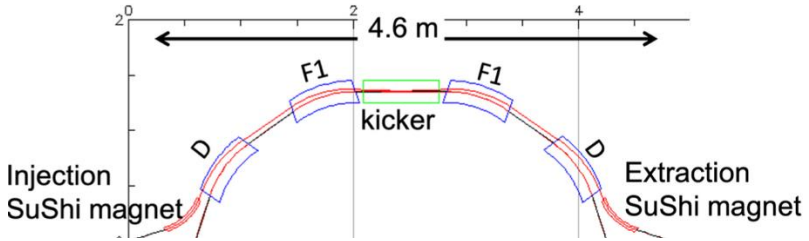




C. García-Ramos

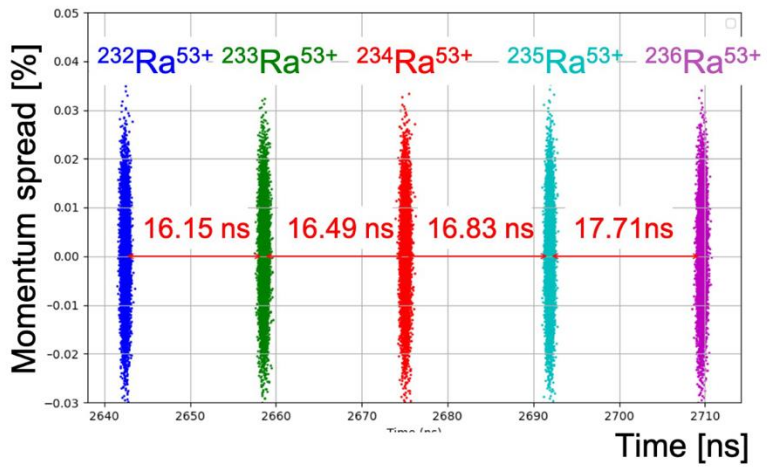
Universidad de Huelva

Injection extraction



Isochronous mode

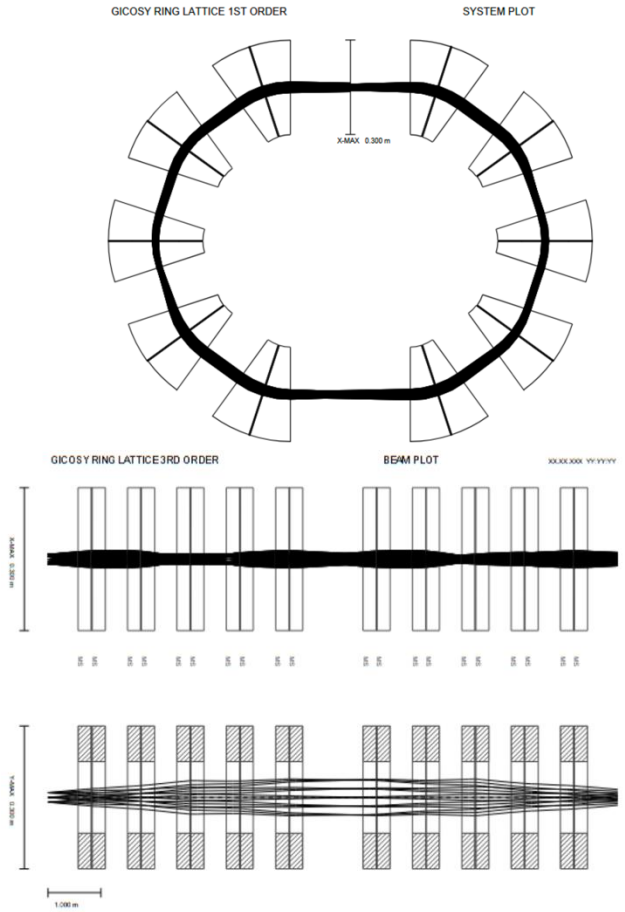
Isotopes separation by ToF after 10 turns (2670 ns)



J. Resta

VNIVERSITAT DE VALÈNCIA

2nd order corrections



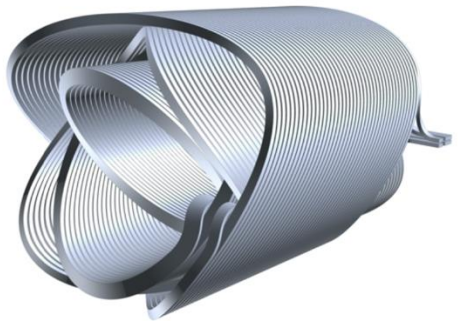
T. Kurtukian-Nieto

CSIC Consejo Superior de Investigaciones Científicas

MAGnet DEMonstrator – MAGDEM

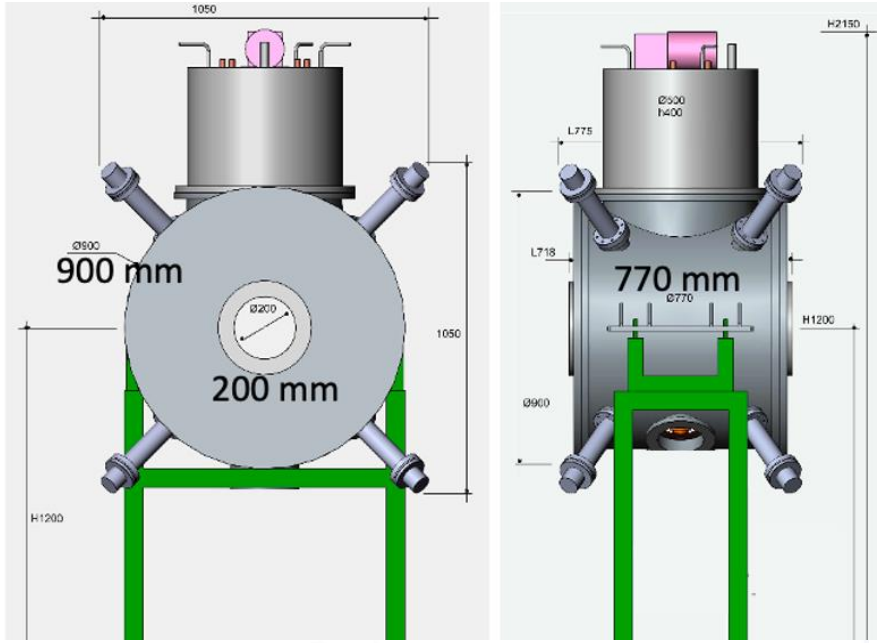
- Multifunction nested SC CCT straight solenoid dipole + quad,
- iron-free, No LHe → cryocooler
- Cryostat Design and Solenoid Integration
- Tender MAGDEM unit

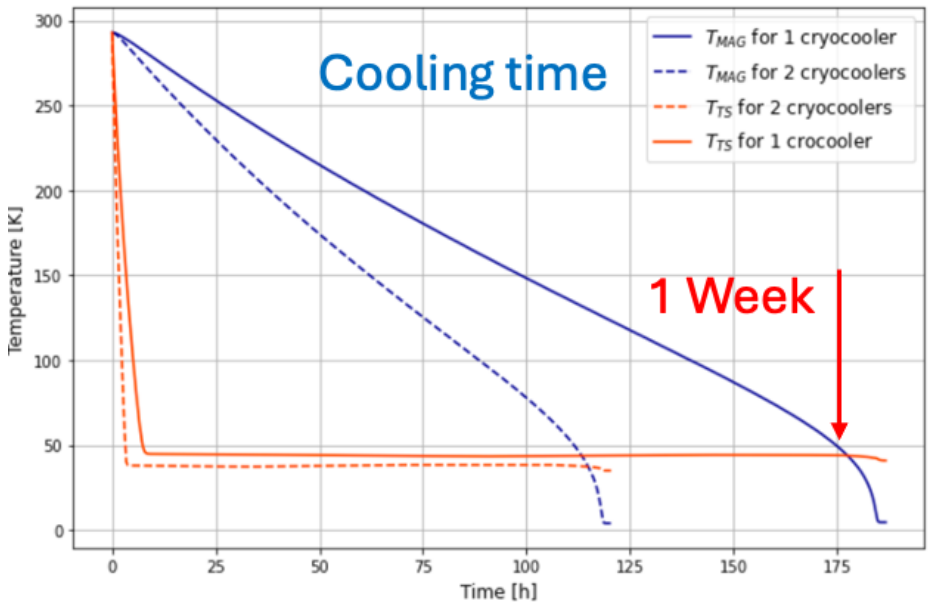
Dipole field integral	> 0.74 T m
Peak field dipole	> 2.35 T
Quadrupole field integral	> 0.24 T m
Quadrupole gradient	> 10 T/m
Superconductor	NbTi
Operational current	< +/- 120 A

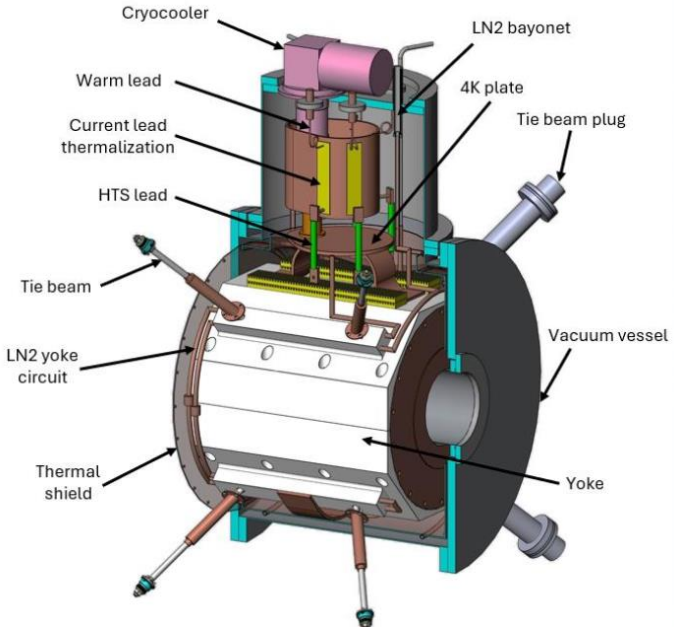


Nested dipole + quadrupole

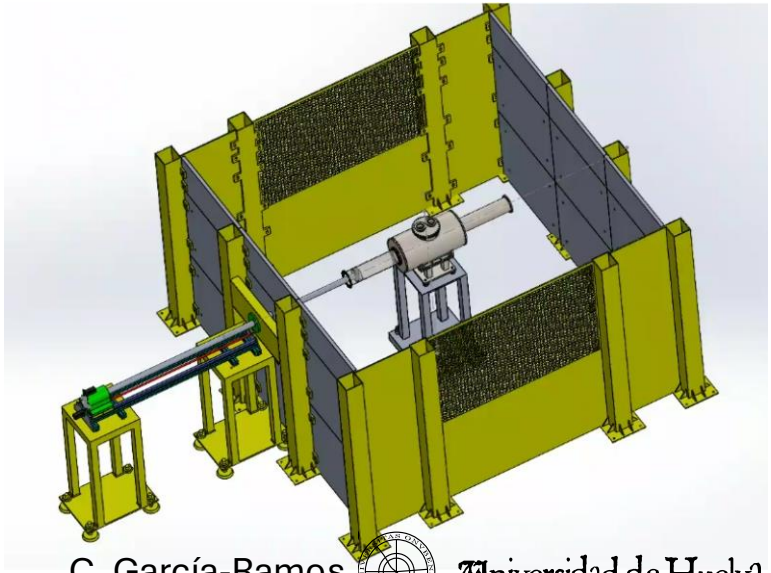
A. Iziquel et al., ICEC2024
G. Kirby et al. ASC2024





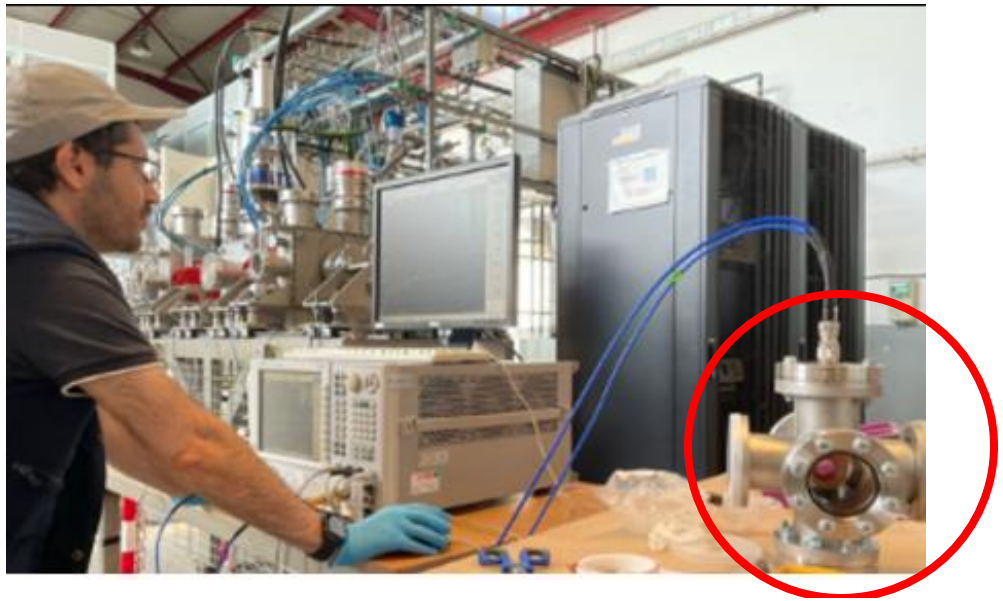


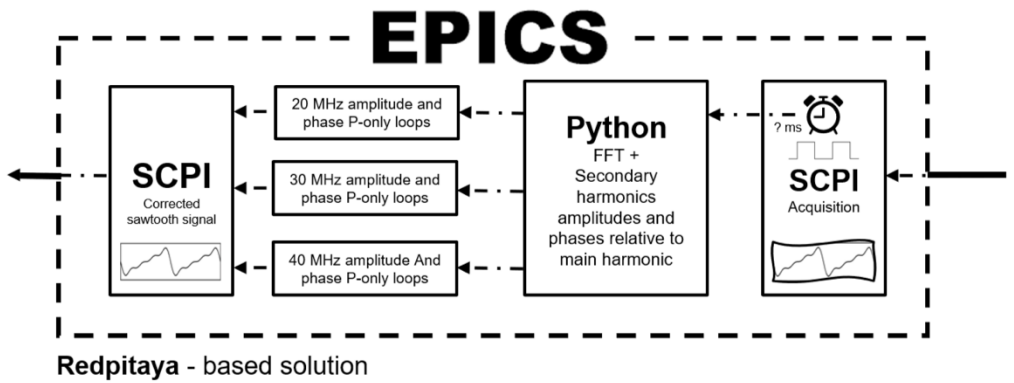
Magnetic field measuring system



C. García-Ramos Universidad de Huelva

Multiharmonic buncher





Redpitaya - based solution

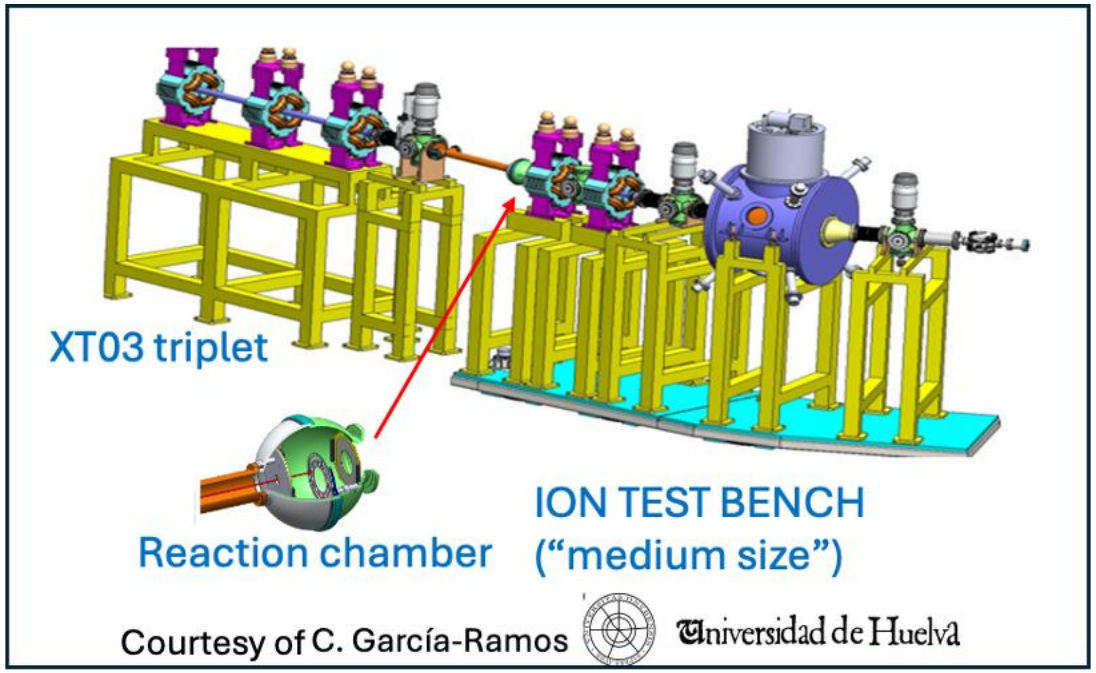
Courtesy of I. Bustinduy ESS bilbao

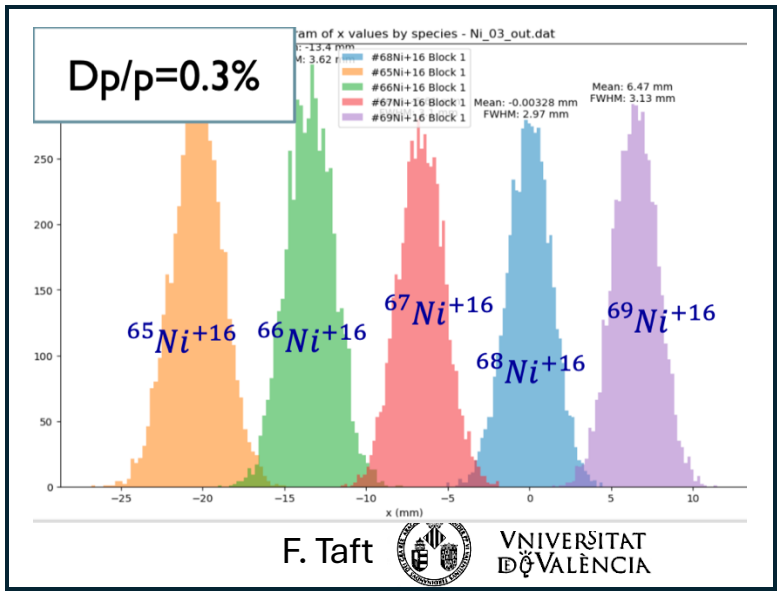
MAGDEM ion test bench

Characterised MAGDEM → ISRS beam dynamics, mass selectivity

- ✓ MAGDEM
- ✓ Reaction chamber
- ✓ Focussing system
- ✓ Focal plane detector
- ✓ Beam diagnostics
- ✓ Rotatory platform

- Three phases (low, medium, high) → beyond present project
  - ✓ MAGDEM ion tests
  - ✓ Mass selectivity tests
  - ✓ Spectrometer
  - ✓ LOI next INTC (Feb 2024)





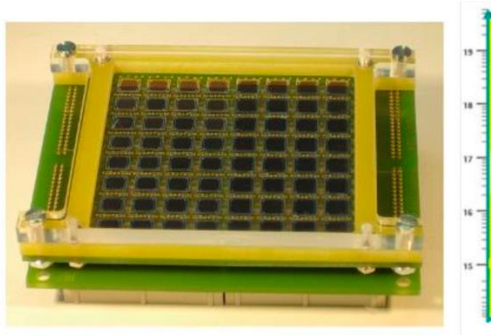
ACTIVITY	INSTITUTE	2025 Q1	2025 Q2	2025 Q3	2025 Q4	2026 Q1	2026 Q2	2026 Q3	2026 Q4	2027 Q1	2027 Q2	2027 Q3	2027 Q4	2028 Q1	2028 Q2	2028 Q3	2028 Q4
1. BEAM TRANSPORT AND INTEGRATION STUDIES	VALENCIA-MADRID-HUELVA																
2. ACQUISITION OF SUBSYSTEMS	HUELVA-MADRID																
3. INTEGRATION LAB-UHU	HUELVA																
4. OFF-LINE TESTS LAB-UHU	HUELVA																
5. TRANSPORT/COMMISSIONING CMAM	MADRID																
6. ON-LINE TESTS CMAM	MADRID																
7.TRANSPORT/COMMISSIONING HIE-ISOLDE	ISOLDE																

Present project

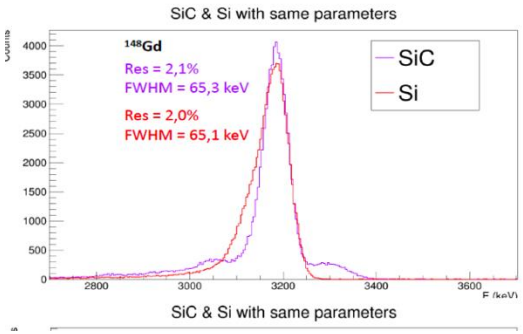
LS3

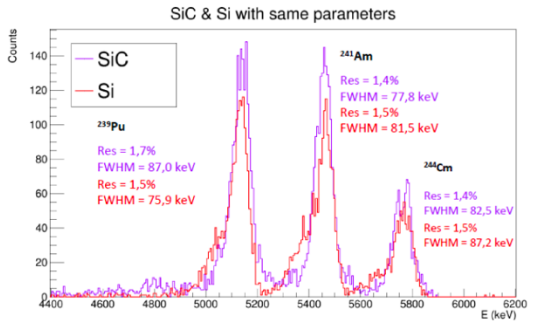
Focal plane detector

Monolithic Si Detector



SiC developed at IMB-CSIC

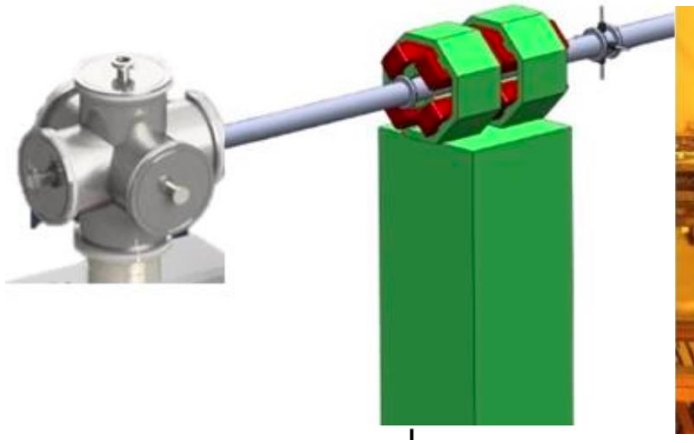


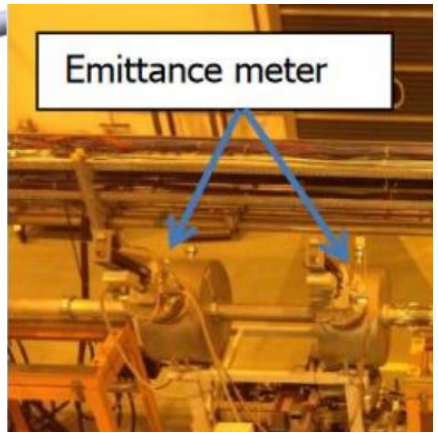


L. Acosta

CSIC
Consejo Superior de Investigaciones Científicas

MAGDEM test bench/focussing





CMAM Madrid

T. Kurtukian-Nieto

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NEXT TALK

Test bench for the ISOLDE Superconducting Recoil Separator ISRS — *Sergio Sanchez Navas*

503/1-001 - Council Chamber, CERN — 12:30 - 12:42

STATUS OF THE R&D ACTIVITIES

1st July 2023 — 25 November 2024 — 31 Dec. 2025

	WORK PACKAGE	2023	2024				2025			
		1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27
WP1	STUDY OF BEAM DYNAMICS, INJECTION AND EXTRACTION SYSTEMS					60%				
WP2	CCT SOLENOIDS AND CRYOSTATS					60%				
WP3	MULTIHARMONIC BUNCHER					90%				

%	COMPLETED

EXTENDED PERIOD			
2026			
16-18	19-21	22-24	25-27
←	→		

POSTER SESSION

- Beam dynamics of ISRS. Javier Resta, Univ. Valencia
- ISRS Nuclear reactions calculations. Fatemeh Torabi, Univ. Huelva
- Magnetic field measuring system. Rafael Berjillos, Univ. Huelva
- ISRS Reaction chamber. Carlos García, Univ. Huelva
- MAGDEM prototype. Carlos Alejandro González, Univ. Huelva
- MAGDEM ion test bench. Domingo Gómez, Univ. Huelva.

SUMMARY AND CONCLUSIONS

ISOLDE Superconducting Recoil Separator

- First design studies completed
- Construction of prototypes is progressing
- Ion tests at HIE-ISOLDE post LS3 (new LOI)

The ISRS Collaboration LOI-INTC-228 (2021)

Dpt. CC Integradas, Univ. Huelva, Spain.
Dpt. of Physics, Univ. Liverpool, UK.
ICMUV, Univ. de Valencia, Spain
IEM, CSIC, Madrid, Spain.
ESS- BILBAO, Bilbao, Spain.
Dpt. of Physics, Lund Univ., Sweden.
Dpt. of Physics, Chalmers Univ. of Technology, Göteborg, Sweden.
CENGB, Gradignan, France.
Dpt. of Physics, Univ. York, UK.
Univ. West Scotland, UK.
Cockcroft Institute, Daresbury, UK.

APC, Paris, France.
Univ. Jyvaskyla, Finland.
IFIN-HH, Bucharest, Romania.
Inst. de Física, UNAM, México.
IPNO, Univ. Paris-Sud, Orsay, France.
Uppsala Univ., Sweden.
CERN, Geneva, Switzerland.
Dpt. of Physics, Univ. Surrey, UK.
Univ. Edinburgh, UK.
IMIS Univ., Riyadh, Saudi Arabia.
LNL INFN, Italy.
Dpt. of Physics and Astronomy, Aarhus Univ., Denmark.

THANKS

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